TECHNICAL MEMORANDUM

MONTGOMERY WATSON

To:	Michael McGuire, Ph.D. McGuire Environmental Consultants, Inc.	**Date:**	March 11, 1998
From:	Issam Najm, Ph.D., P.E. Lina Boulos		
Copies to:	Rhodes Trussell; Dennis Clifford; Brian Gallagher; David Ebersold		
Client:	Main San Gabriel Basin Watermaster		
Project:	Application of Ion-Exchange for Perchlorate Removal		
Subject:	Experimental Plan for Bench-Scale Testing		

The Main San Gabriel Valley Watermaster (Watermaster) retained the services of Montgomery Watson (MW) to conduct a bench- and pilot-scale treatability study to evaluate the removal of perchlorate from contaminated San Gabriel Basin groundwater using conventional ion-exchange (IX) processes. This document contains the experimental plan to be implemented at the bench-scale tests. The pilot-scale testing plan will be developed after the bench-scale tests are concluded.

The document begins with a general description of the testing approach, followed by a description of the experimental setup, and then a detailed description of the specific tests to be conducted. This last section will include all the testing procedures, the number, location, and frequency of sampling, and the analytical requirements of each collected sample.

GENERAL APPROACH

The project approach is divided into two Phases. Phase I includes bench-scale testing, and Phase II includes Pilot-Scale testing. The bench-scale tests will be conducted in Montgomery Watson's research laboratory in Monrovia, California, while the pilot-scale testing will be conducted under field conditions at the Big Dalton Well treatment plant in Baldwin Park.

Phase I: Bench-Scale Testing

The bench-scale testing will focus on three specific areas:

1. Screening of three alternative IX resins,
2. Evaluating resin regeneration efficiency, and

3. Evaluating biological treatment for the removal of perchlorate and nitrate from the spent regenerate brine

The groundwater to be used will be obtained from the Valley County Water District's (VCWD's) Big Dalton Well water treatment plant. Based on the perchlorate concentration in the water samples collected, ammonium perchlorate will be added in order to adjust the perchlorate concentration in the water samples to 200 µg/L prior to testing. why 200?

The resins evaluated were selected during the project kick-off workshop conducted on Tuesday, March 10th. Three columns will be set up and operated in parallel. Each column will contain different resin. The following three resins were selected:

- Strong Base Anion (SBA) polyacrylic resin A458 (Rhom & Haas). This resin has a moderate affinity to perchlorate, and will thus have a high regeneration efficiency. A 90% perchlorate recovery is expected after only two run cycles.
- Strong Base Anion (SBA) polystyrene resin ASB2 (Sybron). This resin has a high affinity for perchlorate, and may require more than 4 cycles to reach steady-state regeneration efficiency.
- Strong Base Anion (SBA) polystyrene resin A400 (Rohm & Haas). This resin has a very high affinity for perchlorate. A long exhaustion run is expected before perchlorate breakthrough takes place.

Each column will be operated until perchlorate breakthrough takes place. At that time, the resin will be regenerated using fresh brine, and then put back in service for the next cycle. The bench-scale testing will be conducted over a maximum period of 6 weeks in order to allow for a minimum of five cycles for each resin. This is important because the capacity of the resin may diminish over time due to incomplete regeneration between cycles.

The spent brine will contain chloride, bicarbonate, nitrate, sulfate, and perchlorate. Biological removal of perchlorate from the brine will be implemented with the goal of reducing the waste volume. A Sequencing Batch Reactor (SBR) will be used as the biological process. Montgomery Watson, with the help of the Watermaster, will contact AEROJET to obtain a perchlorate-acclimated bacterial seed from their ongoing biological treatment testing efforts.

Phase II: Pilot-Scale Testing

The pilot-scale testing will focus on demonstrating that the laboratory results obtained during Phase I can be applied under field conditions. As such, the pilot testing will evaluate one IX resin to be selected based on the result of the Phase I bench-scale testing. The pilot plant will be set up at VCWD's Big Dalton Well water treatment plant. The pilot plant will draw water from the influent groundwater to the full-scale GAC columns, which is reported to contain 30 to 100 µg/L perchlorate. No perchlorate spiking of the influent groundwater will be conducted. The column will be operated under ambient conditions for a period of 8 weeks during which multiple regeneration cycles are anticipated. No biological treatment of the spent brine will be conducted at the pilot plant, and thus a fresh brine solution will be used for each regeneration. The influent

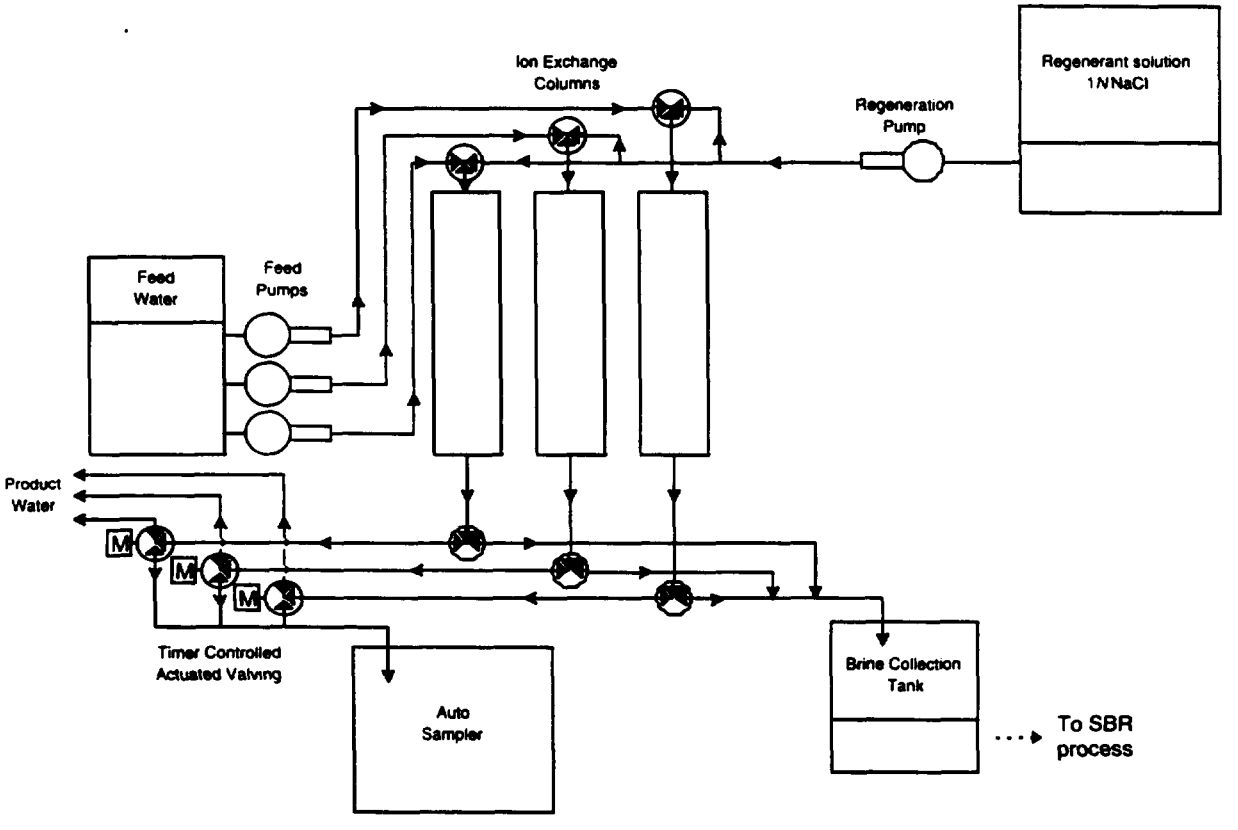
and effluent perchlorate concentrations - as well as other anions - will be monitored during the pilot study.

As noted above, this document is limited to the bench-scale testing. The pilot-scale testing plan will be developed at the conclusion of the bench-scale experiments.

PHASE I: BENCH-SCALE TESTING

Bench-Scale Experimental Setup

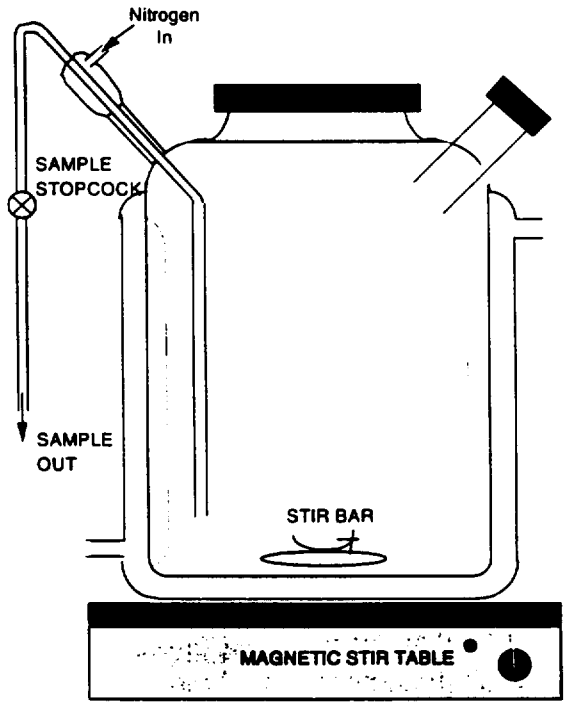
The experimental set-up of the bench-scale IX columns is illustrated in Figure 1. Three glass columns will be set up to run in parallel. Each column will be 11-mm in diameter (ID) and 300 mm high. Each column will contain 21 cm of resin media (which translates into 20 mL of resin) to allow for a 30% bed expansion. The columns will be operated in a co-current mode, with down-flow service and regeneration. Screens will be inserted at the top and bottom of each column to contain the resin in the column during operation and regeneration.



IX Bench-Scale Experimental Set-Up

Figure 1

Spent regenerate brine will be fed to a 3-L SBR for evaluating the biodegradation of perchlorate in a high-TDS brine solution. The SBR will be covered and vented to the outside. A schematic of the SBR is shown in Figure 2. The reactor will be made of glass, and will be operated under a nitrogen atmosphere to maintain it under anoxic conditions. Spent brine will first be collected in a holding tank, and then fed to the SBR in batches. The reactor will be placed on a magnetic stirrer for mixing, and will have sampling ports to allow for the monitoring of perchlorate concentration over time. Once the perchlorate is completely biodegraded, the regenerate will be decanted, filtered through a 1 μm filter paper, and analyzed for the various anions of concern. A more detailed description of this process is discussed later.



Schematic of the SBR for Brine Treatment

Figure 2

Source Water

The water sample to be used for the bench-scale testing will be obtained from the Big Dalton well plant in Baldwin Park. Table 1 lists the values of the relevant water quality parameters in the groundwater based on three water samples collected in November 95, August 97, and September 97.

Table 1

Average Water Quality Parameters in the Groundwater at the Big Dalton Well Plant

Parameter	Unit	Value
Alkalinity	mg/L as $CaCO_3$	139
pH	-	7.4
Bicarbonate (HCO_3^-)	mg/L	170
Sulfate (SO_4^{2-})	mg/L	39
Chloride (Cl^-)	mg/L	42
Nitrate (NO_3^-)	mg/L as NO_3^-	20
Specific Conductance	umho/cm	472

It is estimated that a total of 100 gallons of water will be needed every week. Since the intent is to use actual groundwater for the bench-scale testing, Montgomery Watson field staff will transport a 100-gallon container to the Big Dalton Well plant, collect 100 gallons of water, and transport them back to the laboratory. This will be conducted every Thursday morning. A sample will be collected from the water and screened for anions, including perchlorate. Based on the analytical results obtained, the water will be spiked with sufficient perchlorate on Friday to result in a perchlorate concentration of 200 µg/L. The sample will be stirred for 1 hour, and stored at 4°C over the weekend to minimize any deterioration in water quality.

Each batch of water will be analyzed for the following: perchlorate, nitrate, sulfate, chloride, bicarbonate, carbonate, alkalinity, pH, TOC, UV-254 absorbance, and hardness.

Testing Conditions

This section details the experiments to be conducted, including 1) setting up the resin in each column, 2) column operation, 3) resin regeneration, and 4) biological brine treatment. Since all three columns will be operated identically, the following discussion will apply to each column.

Column & Resin Setup

Each column will first be half-filled with DI water. The resin will then be added from the top and allowed to settled to the bottom of the column. Resin should be added until the settled resin level reaches the 21-cm (8¼-inch) mark. Resin should always be added with excess water in the column so as to prevent the formation of air-gaps in the packed resin. Once the full amount of resin is added, the column will be filled with DI water, and then set in place.

IX Resin Operation

The general operating conditions for each column will be to continuously feed the resin with the spiked groundwater at a constant flow rate, collect sufficient influent and effluent samples for

anion analysis to establish a clear breakthrough curve for nitrate, sulfate and perchlorate. A computer model was used to predict specific anion breakthroughs for the first and second run cycles. For the first run, it was found that once nitrate and sulfate breakthroughs are reached (after 13 and 18 hours, respectively), perchlorate would breakthrough after 12 days. For the second cycle, the perchlorate breakthrough run time is expected to decrease significantly to 1 to 2 days. The run will be terminated once perchlorate breakthrough takes place.

The operating conditions for each column are listed in Table 2. The resin will be operated at a loading rate of 4.8 gpm/ft^3. With a resin volume of 20 mL in each column, the water flow rate to each column is estimated at 12.8 mL/min. This translates into an Empty Bed Contact Time (EBCT) of 1.5 minutes.

Table 2

Resin Operating Conditions

Parameter	Unit	Value
Resin Loading Rate	gpm/ft^3	4.8
Resin Volume	mL	20
Flow Rate	mL/min	12.8

The breakthrough profile of the various anions, and thus the run time, will depend on the resins selected and the number of runs. The over run time may vary from one day to two weeks. As such, it is not possible to estimate the breakthrough profile at this time, and thus the regeneration frequency. The objective during column operation is to collect a minimum of five samples along the breakthrough profile of each anion, especially nitrate and perchlorate, during each cycle. It is anticipated that the anion breakthrough sequence will be as follows:

$$HCO_3^- \Rightarrow NO_3^- \Rightarrow SO_4^{2-} \Rightarrow ClO_4^-$$

However, this sequence may change as the number of cycles increases. For example, if the regeneration of perchlorate on one resin is inefficient, the perchlorate breakthrough curve may continuously shift backwards as we move from the first, to the second, to the third operating cycles. As such, it will not be possible to capture the exact time of breakthrough of each anion from information obtained during the first cycle alone. With this limitation, it is important that samples be collected with such a high frequency that no breakthrough profile will be missed. Therefore, for the first cycle run, one effluent sample should be collected from each column every two (2) hours for the first 20 hours. These samples will be analyzed for pH, nitrate and sulfate. The run, and the sampling (one sample every 2 hours), will continue thereafter until perchlorate breakthrough takes place. Considering that a 200-mL sample is required for all the analyses, and that the flow rate is set at 12.8 mL, a total of 16 minutes are required to collect each sample.

However, only a fraction of the samples will be sent to Montgomery Watson laboratories for perchlorate analyses, while the remaining samples will be stored in the refrigerator until the perchlorate results return from the laboratory. As a starting point, the perchlorate samples will be selected as follows: Since perchlorate breakthrough is anticipated to occur after nitrate and sulfate, a total of two samples will be analyzed in the first 20 hours. A total of eight (8) samples will be selected to cover the period starting from sulfate breakthrough, and ending two weeks later. The results, which will be obtained from the laboratory within 24 hours, will be analyzed. If the perchlorate breakthrough profile is well captured, then none of the standby samples will be sent for perchlorate analysis. However, if the breakthrough profile was not captured by the ten (10) selected samples, specific standby samples will be selected and sent to the laboratory for perchlorate analysis.

This sampling scenario will have to be revised for the next service cycles once the breakthrough profiles of the first run cycle are obtained. It is anticipated that perchlorate will breakthrough after a one- to day period during the second cycle. In this case, effluent samples will be collected every two hours until perchlorate breakthrough is obtained. Every third sample (a total of eight samples in the first 48 hours)will be analyzed for nitrate, sulfate and perchlorate.

It should be noted that the influent water should be analyzed for the above-listed anions, including perchlorate, approximately three times during each run.

Appendix A contains the raw data sheets to be used in each experiment. These forms will be used for full documentation of the sample collection frequency, analytical frequency, analytical results, and operational conditions.

IX Resin Regeneration

Resin regeneration will take place after all primary anion breakthroughs take place (i.e., bicarbonate, nitrate, sulfate, and perchlorate). Once breakthrough takes place, the water flow will be stopped, and the resin will be regenerated.

As noted earlier, resin regeneration will be conducted in a down-flow mode. The regeneration parameters are listed in Table 3. The regeneration brine will be composed of 1.0 N (6% or 60,000 mg/L) solution of sodium chloride (NaCl). The regeneration flow rate will be set at 3.5 mL/min, which translates into a regeneration rate of 5.7 min/BV. The total target salt loading rate will be set at 15 lbs/ft^3. Therefore, the regeneration period is estimated at 23 minutes (or 4 BVs). The brine solution will be collected and analyzed for chloride, bicarbonate, nitrate, sulfate, and perchlorate. Considering the high TDS of the sample, special pretreatment may be required to measure the anion concentrations in the samples without excessive dilution, which will otherwise result in substantially raising the analytical detection limits. After the results from the first regeneration are obtained and analyzed, the regeneration procedure may be revised to improve regeneration efficiency.

Table 3

Resin Regeneration & Rinsing Conditions

Parameter	Unit	Value
Regenerate Type	-	NaCl
Regenerate Strength	N	1.0
	%	6%
	mg/L	60,000
Max. Salt Loading Rate	lbs/ft^3	15
Regenerate Flowrate	mL/min	3.5
Regeneration Time	min	23
Rinse Water	Low-ClO_4^- treated groundwater	
Rinse Period	min	10

Each column will be rinsed after each regeneration. Pre-stored low-perchlorate treated groundwater will be used for rinsing. It is important that the water be low in all anions other than chloride. As such, the rinse water will be collected over a period of 10 minutes starting from 5 minutes after the start of the column run. This should collect enough water for rinsing one column. After the regenerate flow is stopped, the rinse water will be fed at 3.5 mL/min for a period of 10 minutes (Table 3). This represents approximately 1.75 BVs. The influent water will be analyzed for chloride concentration. The effluent rinse water will also be collected and analyzed for chloride.

Biological Brine Treatment

As noted earlier, biodegradation of the perchlorate present in the brine will be conducted in a SBR (see Figure 2). Under anoxic conditions, perchlorate is used as the electron acceptor according to the following half-reaction:

$$ClO_4^- + 8e^- + 8H^+ \Rightarrow Cl^- + 4H_2O \quad (1)$$

The electrons are then used by the microorganisms to convert organic carbon to cell mass and CO_2. To accomplish this, methanol will be added as the carbon source. The oxidation half-reaction from methanol to CO_2 is then:

$$CH_3OH + OH^- \Rightarrow 6e^- + CO_2 + 5H^+ \quad (2)$$

Reactions 1 and 2 are then combined into Reaction 3:

$$3ClO_4^- + 4CH_3OH + \Rightarrow 3Cl^- + 4CO_2 + 8H_2O \quad (3)$$

Based on Reaction 3, approximately 0.43 mg of methanol are required for each mg of perchlorate removed. However, Reaction 3 is not completely accurate because a significant portion of the

carbon will be converted to cell mass. This portion can amount to 20 to 40% of the carbon present. In addition, the nitrate present in the brine will be biodegraded before perchlorate according to the following half-reaction:

$$2NO_3^- + 10e^- + 12H^+ \Rightarrow N_2 + 6H_2O \quad (4)$$

Combining the methanol half-reaction (Reaction 2) and Reaction 4 results in the following reaction:

$$6NO_3^- + 5CH_3OH + 6H^+ \Rightarrow 3N_2 + 5CO_2 + 13H_2O \quad (5)$$

Reaction 5 also suggests that a methanol-to-nitrate ratio of 0.43 mg/mg is required. However, considering that the concentration of nitrate in the brine will be approximately 2 orders of magnitude higher than that of perchlorate, Reaction 5 will determine the amount of methanol required for the biodegradation of both nitrate and perchlorate.

The regenerate brine used in the biodegradation testing will be analyzed for nitrate and perchlorate concentrations. Based on the nitrate concentration, the regenerate will be spiked with 0.5 mg/mg methanol to nitrate concentration. The methanol-to-nitrate concentration ratio of 0.5 is greater than that calculated based on Reaction 5 (i.e., 0.43 mg/mg) to account for the fraction of the methanol that will be used for biomass generation. The spiked regenerate will then be introduced to the SBR and then spiked with 1000 mg/L VLSS from the bacterial seed sample. The sample will then be mixed for a period of 72 hours, during which samples will be withdrawn every 12 hours and immediately analyzed for nitrate. If the nitrate concentration is measured at less than 1 mg/L, the sample will then be sent to Montgomery Watson laboratories for perchlorate analysis. Mixing and perchlorate sampling (every 30 minutes) will continue until the perchlorate concentration in the brine is reported at less than 10 ug/L. At that time, the mixer will be turned off, and the water will be allowed to settle for a period of 4 hours. The supernatant will then be withdrawn, filtered through a 1-um filter paper, and analyzed for chloride, bicarbonate, nitrate, sulfate, and perchlorate.

San Gabriel Basin Perchlorate Treatment Study
Bench-scale Ion-Exchange Data Sheet

Test Cycle:	1
Column Number:	1
Resin Manufacturer:	
Resin Descriptor:	

Column Dimensions / Resin Volume		
Column ID:	11	mm
Total column height:	30	cm
Resin height:	21	cm
Resin bed volume:	**20.0**	mL

Service Operational Data		
Service Flow Direction:	Downflow	
Service Flow Rate:	12.75	mL/min
Service Loading Rate:	**4.8**	gpm/ft^3

Regeneration Operational Data		
Flow Direction:	Upflow	
Regenerant:	NaCl	
Regenerant Conc.:	6	%
Flow Rate:	3.5	mL/min
Regeneration Time:	23	min
Salt Loading Rate:	**15.1**	lb NaCl/ft^3

Run-Termination Condition	
100%	Nitrate and Sulfate breakthrough
	Reach perchlorate breakthrough

				MW Lab		ARD Lab							Influent	Effluent
Sample Number	Target Sample Time	Actual Sample Time	Actual BV	Lab Sample ID	Perchlorate (ug/L)	Nitrate (mg/L-N)	Sulfate (mg/L)	Bicarbonate (mg/L)	Chloride (mg/L)	Temperature (degC)	pH		Pressure (psig)	Pressure (psig)
INFLUENT WATER QUALITY														
1				T1-INF-1										
2				T1-INF-2										
3				T1-INF-3										
4				T1-INF-4										
5				T1-INF-5										
6				T1-INF-6										
7				T1-INF-7										
	Influent Average				#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!			

Run Start Time:	

					MW lab	ARD Lab						Influent	Effluent
Sample Number	Target Sample Time	Actual Sample Time	Actual BV	Lab Sample ID	Perchlorate (ug/L)	Nitrate (mg/L-N)	Sulfate (mg/L)	Bicarbonate (mg/L)	Chloride (mg/L)	Temperature (degC)	pH	Pressure (psig)	Pressure (psig)
EFFLUENT DATA													
1	1/0/00 2:00			T1-C1-EFF-1									
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4	1/0/00 8:00			T1-C1-EFF-4									
5	1/0/00 10:00			T1-C1-EFF-5									
6	1/0/00 12:00			T1-C1-EFF-6									
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22	1/1/00 20:00			T1-C1-EFF-22									
23	1/1/00 22:00			T1-C1-EFF-23									
24	1/2/00 0:00			T1-C1-EFF-24									

San Gabriel Basin Perchlorate Treatment Study
Bench-scale Ion-Exchange Data Sheet

Test Cycle:	1
Column Number:	1
Resin Manufacturer:	
Resin Descriptor:	

Column Dimensions / Resin Volume		
Column ID:	11	mm
Total column height:	30	cm
Resin height:	21	cm
Resin bed volume:	**20.0**	mL

Service Operational Data		
Service Flow Direction:	Downflow	
Service Flow Rate:	12.75	mL/min
Service Loading Rate:	**4.8**	gpm/ft^3

Regeneration Operational Data		
Flow Direction:	Upflow	
Regenerant:	NaCl	
Regenerant Conc.:	6	%
Flow Rate:	3.5	mL/min
Regeneration Time:	23	min
Salt Loading Rate:	**15.1**	lb NaCl/ft^3

Run-Termination Condition	
100%	Nitrate and Sulfate breakthrough
	Reach perchlorate breakthrough

				MW Lab		ARD Lab						Influent	Effluent
Sample Number	Target Sample Time	Actual Sample Time	Actual BV	Lab Sample ID	Perchlorate (ug/L)	Nitrate (mg/L-N)	Sulfate (mg/L)	Bicarbonate (mg/L)	Chloride (mg/L)	Temperature (degC)	pH	Pressure (psig)	Pressure (psig)
25	1/2/00 2:00			T1-C1-EFF-25									
26	1/2/00 4:00			T1-C1-EFF-26									
27	1/2/00 6:00			T1-C1-EFF-27									
28	1/2/00 8:00			T1-C1-EFF-28									
29	1/2/00 10:00			T1-C1-EFF-29									
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34	1/2/00 20:00			T1-C1-EFF-34									
35	1/2/00 22:00			T1-C1-EFF-35									
36	1/3/00 0:00			T1-C1-EFF-36									
37	1/3/00 2:00			T1-C1-EFF-37									
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39	1/3/00 6:00			T1-C1-EFF-39									
40	1/3/00 8:00			T1-C1-EFF-40									
41	1/3/00 10:00			T1-C1-EFF-41									
42	1/3/00 12:00			T1-C1-EFF-42									
43	1/3/00 14:00			T1-C1-EFF-43									
44	1/3/00 16:00			T1-C1-EFF-44									
45	1/3/00 18:00			T1-C1-EFF-45									
46	1/3/00 20:00			T1-C1-EFF-46									
47	1/3/00 22:00			T1-C1-EFF-47									
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49	1/4/00 2:00			T1-C1-EFF-49									
50	1/4/00 4:00			T1-C1-EFF-50									
51	1/4/00 6:00			T1-C1-EFF-51									
52	1/4/00 8:00			T1-C1-EFF-52									
53	1/4/00 10:00			T1-C1-EFF-53									
54	1/4/00 12:00			T1-C1-EFF-54									
55	1/4/00 14:00			T1-C1-EFF-55									
56	1/4/00 16:00			T1-C1-EFF-56									
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58	1/4/00 20:00			T1-C1-EFF-58									
59	1/4/00 22:00			T1-C1-EFF-59									
60	1/5/00 0:00			T1-C1-EFF-60									
61	1/5/00 2:00			T1-C1-EFF-61									

San Gabriel Basin Perchlorate Treatment Study
Bench-scale Ion-Exchange Data Sheet

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Regenerant:	NaCl	
Regenerant Conc.:	6	%
Flow Rate:	3.5	mL/min
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Salt Loading Rate:	15.1	lb NaCl/ft^3

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62	1/5/00 4:00			T1-C1-EFF-62									
63	1/5/00 6:00			T1-C1-EFF-63									
64	1/5/00 8:00			T1-C1-EFF-64									
65	1/5/00 10:00			T1-C1-EFF-65									
66	1/5/00 12:00			T1-C1-EFF-66									
67	1/5/00 14:00			T1-C1-EFF-67									
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71	1/5/00 22:00			T1-C1-EFF-71									
72	1/6/00 0:00			T1-C1-EFF-72									
73	1/6/00 2:00			T1-C1-EFF-73									
74	1/6/00 4:00			T1-C1-EFF-74									
75	1/6/00 6:00			T1-C1-EFF-75									
76	1/6/00 8:00			T1-C1-EFF-76									
77	1/6/00 10:00			T1-C1-EFF-77									
78	1/6/00 12:00			T1-C1-EFF-78									
79	1/6/00 14:00			T1-C1-EFF-79									
80	1/6/00 16:00			T1-C1-EFF-80									
81	1/6/00 18:00			T1-C1-EFF-81									
82	1/6/00 20:00			T1-C1-EFF-82									
83	1/6/00 22:00			T1-C1-EFF-83									
84	1/7/00 0:00			T1-C1-EFF-84									
85	1/7/00 2:00			T1-C1-EFF-85									
86	1/7/00 4:00			T1-C1-EFF-86									
87	1/7/00 6:00			T1-C1-EFF-87									
88	1/7/00 8:00			T1-C1-EFF-88									
89	1/7/00 10:00			T1-C1-EFF-89									
90	1/7/00 12:00			T1-C1-EFF-90									
91	1/7/00 14:00			T1-C1-EFF-91									
92	1/7/00 16:00			T1-C1-EFF-92									
93	1/7/00 18:00			T1-C1-EFF-93									
94	1/7/00 20:00			T1-C1-EFF-94									
95	1/7/00 22:00			T1-C1-EFF-95									
96	1/8/00 0:00			T1-C1-EFF-96									
97	1/8/00 2:00			T1-C1-EFF-97									
98	1/8/00 4:00			T1-C1-EFF-98									

San Gabriel Basin Perchlorate Treatment Study
Bench-scale Ion-Exchange Data Sheet

Test Cycle:	1
Column Number:	1
Resin Manufacturer:	
Resin Descriptor:	

Column Dimensions / Resin Volume		
Column ID:	11	mm
Total column height:	30	cm
Resin height:	21	cm
Resin bed volume:	**20.0**	mL

Service Operational Data		
Service Flow Direction:	Downflow	
Service Flow Rate:	12.75	mL/min
Service Loading Rate:	**4.8**	gpm/ft^3

Regeneration Operational Data		
Flow Direction:	Upflow	
Regenerant:	NaCl	
Regenerant Conc.:	6	%
Flow Rate:	3.5	mL/min
Regeneration Time:	23	min
Salt Loading Rate:	**15.1**	lb NaCl/ft^3

Run-Termination Condition	
100%	Nitrate and Sulfate breakthrough
	Reach perchlorate breakthrough

				MW Lab		ARD Lab						Influent	Effluent
Sample Number	Target Sample Time	Actual Sample Time	Actual BV	Lab Sample ID	Perchlorate (ug/L)	Nitrate (mg/L-N)	Sulfate (mg/L)	Bicarbonate (mg/L)	Chloride (mg/L)	Temperature (degC)	pH	Pressure (psig)	Pressure (psig)
99	1/8/00 6:00			T1-C1-EFF-99									
100	1/8/00 8:00			T1-C1-EFF-100									
101	1/8/00 10:00			T1-C1-EFF-101									
102	1/8/00 12:00			T1-C1-EFF-102									
103	1/8/00 14:00			T1-C1-EFF-103									
104	1/8/00 16:00			T1-C1-EFF-104									
105	1/8/00 18:00			T1-C1-EFF-105									
106	1/8/00 20:00			T1-C1-EFF-106									
107	1/8/00 22:00			T1-C1-EFF-107									
108	1/9/00 0:00			T1-C1-EFF-108									
109	1/9/00 2:00			T1-C1-EFF-109									
110	1/9/00 4:00			T1-C1-EFF-110									
111	1/9/00 6:00			T1-C1-EFF-111									
112	1/9/00 8:00			T1-C1-EFF-112									
113	1/9/00 10:00			T1-C1-EFF-113									
114	1/9/00 12:00			T1-C1-EFF-114									
115	1/9/00 14:00			T1-C1-EFF-115									
116	1/9/00 16:00			T1-C1-EFF-116									
117	1/9/00 18:00			T1-C1-EFF-117									
118	1/9/00 20:00			T1-C1-EFF-118									
119	1/9/00 22:00			T1-C1-EFF-119									
120	1/10/00 0:00			T1-C1-EFF-120									
121	1/10/00 2:00			T1-C1-EFF-121									
122	1/10/00 4:00			T1-C1-EFF-122									
123	1/10/00 6:00			T1-C1-EFF-123									
124	1/10/00 8:00			T1-C1-EFF-124									
125	1/10/00 10:00			T1-C1-EFF-125									
126	1/10/00 12:00			T1-C1-EFF-126									
127	1/10/00 14:00			T1-C1-EFF-127									
128	1/10/00 16:00			T1-C1-EFF-128									
129	1/10/00 18:00			T1-C1-EFF-129									
130	1/10/00 20:00			T1-C1-EFF-130									
131	1/10/00 22:00			T1-C1-EFF-131									
132	1/11/00 0:00			T1-C1-EFF-132									
133	1/11/00 2:00			T1-C1-EFF-133									
134	1/11/00 4:00			T1-C1-EFF-134									
135	1/11/00 6:00			T1-C1-EFF-135									

San Gabriel Basin Perchlorate Treatment Study
Bench-scale Ion-Exchange Data Sheet

Test Cycle:	1
Column Number:	1
Resin Manufacturer:	
Resin Descriptor:	

Column Dimensions / Resin Volume		
Column ID:	11	mm
Total column height:	30	cm
Resin height:	21	cm
Resin bed volume:	**20.0**	mL

Service Operational Data		
Service Flow Direction:	Downflow	
Service Flow Rate:	12.75	mL/min
Service Loading Rate:	**4.8**	gpm/ft^3

Regeneration Operational Data		
Flow Direction:	Upflow	
Regenerant:	NaCl	
Regenerant Conc.:	6	%
Flow Rate:	3.5	mL/min
Regeneration Time:	23	min
Salt Loading Rate:	**15.1**	lb NaCl/ft^3

Run-Termination Condition	
100%	Nitrate and Sulfate breakthrough
	Reach perchlorate breakthrough

				MW Lab		ARD Lab						Influent	Effluent
Sample Number	Target Sample Time	Actual Sample Time	Actual BV	Lab Sample ID	Perchlorate (ug/L)	Nitrate (mg/L-N)	Sulfate (mg/L)	Bicarbonate (mg/L)	Chloride (mg/L)	Temperature (degC)	pH	Pressure (psig)	Pressure (psig)
136	**1/11/00 8:00**			T1-C1-EFF-136									
137	**1/11/00 10:00**			T1-C1-EFF-137									
138	**1/11/00 12:00**			T1-C1-EFF-138									
139	**1/11/00 14:00**			T1-C1-EFF-139									
140	**1/11/00 16:00**			T1-C1-EFF-140									
141	**1/11/00 18:00**			T1-C1-EFF-141									
142	**1/11/00 20:00**			T1-C1-EFF-142									
143	**1/11/00 22:00**			T1-C1-EFF-143									
144	**1/12/00 0:00**			T1-C1-EFF-144									
145	**1/12/00 2:00**			T1-C1-EFF-145									
146	**1/12/00 4:00**			T1-C1-EFF-146									
147	**1/12/00 6:00**			T1-C1-EFF-147									
148	**1/12/00 8:00**			T1-C1-EFF-148									
149	**1/12/00 10:00**			T1-C1-EFF-149									
150	**1/12/00 12:00**			T1-C1-EFF-150									
151	**1/12/00 14:00**			T1-C1-EFF-151									
152	**1/12/00 16:00**			T1-C1-EFF-152									
153	**1/12/00 18:00**			T1-C1-EFF-153									
154	**1/12/00 20:00**			T1-C1-EFF-154									
155	**1/12/00 22:00**			T1-C1-EFF-155									
156	**1/13/00 0:00**			T1-C1-EFF-156									
157	**1/13/00 2:00**			T1-C1-EFF-157									
158	**1/13/00 4:00**			T1-C1-EFF-158									
159	**1/13/00 6:00**			T1-C1-EFF-159									
160	**1/13/00 8:00**			T1-C1-EFF-160									
161	**1/13/00 10:00**			T1-C1-EFF-161									
162	**1/13/00 12:00**			T1-C1-EFF-162									
163	**1/13/00 14:00**			T1-C1-EFF-163									
164	**1/13/00 16:00**			T1-C1-EFF-164									
165	**1/13/00 18:00**			T1-C1-EFF-165									
166	**1/13/00 20:00**			T1-C1-EFF-166									
167	**1/13/00 22:00**			T1-C1-EFF-167									
168	**1/14/00 0:00**			T1-C1-EFF-168									

San Gabriel Basin Perchlorate Treatment Study
Bench-scale Ion-Exchange Data Sheet

Test Cycle:	1
Column Number:	1
Resin Manufacturer:	
Resin Descriptor:	

Column Dimensions / Resin Volume		
Column ID:	11	mm
Total column height:	30	cm
Resin height:	21	cm
Resin bed volume:	**20.0**	mL

Service Operational Data		
Service Flow Direction:	Downflow	
Service Flow Rate:	12.75	mL/min
Service Loading Rate:	**4.8**	gpm/ft^3

Regeneration Operational Data		
Flow Direction:	Upflow	
Regenerant:	NaCl	
Regenerant Conc.:	6	%
Flow Rate:	3.5	mL/min
Regeneration Time:	23	min
Salt Loading Rate:	**15.1**	lb NaCl/ft^3

Run-Termination Condition	
100%	Nitrate and Sulfate breakthrough
	Reach perchlorate breakthrough

					MW lab	ARD Lab							
Sample Number	Target Sample Time	Actual Sample Time	Actual BV	Lab Sample ID	Perchlorate (ug/L)	Nitrate (mg/L-N)	Bicarbonate (mg/L)	Chloride (mg/L)	Sulfate (mg/L)	Temperature (degC)	pH	Influent Pressure (psig)	Effluent Pressure (psig)
BRINE WATER QUALITY													
1				**T1-BRI-1**									
2				**T1-BRI-2**									
3				**T1-BRI-3**									
4				**T1-BRI-4**									
5				**T1-BRI-5**									

					ARD Lab
Sample Number	Target Sample Time	Actual Sample Time	Actual BV	Lab Sample ID	Chloride (mg/L)
RINSE WATER QUALITY					
1				**T1-RIN-1**	
2				**T1-RIN-2**	
3				**T1-RIN-3**	

			ARD Lab		
Sample Number	Target Sample Time	Actual Sample Time	Lab Sample ID	Nitrate mg/L	Perchlorate mg/L
TREATED BRINE QUALITY					
1			**T1-TBRI-1**		
2			**T1-TBRI-2**		
3			**T1-TBRI-3**		
4			**T1-TBRI-4**		
5			**T1-TBRI-5**		
6			**T1-TBRI-6**		
7			**T1-TBRI-7**		
8			**T1-TBRI-8**		
9			**T1-TBRI-9**		
10			**T1-TBRI-10**		